

The effect of trap spacing on the capture of brown tree snakes on Guam

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Abstract

Trapping is central to the integrated control programme to deter brown tree snakes from entering the outbound cargo flow from Guam. Trapping brown tree snakes is effective, but labour intensive. Increasing inter-trap spacings without loss of efficacy could substantially increase the efficiency of efforts to prevent dispersal of this species. Inter-trap spacings of 20, 30 and 40 m along perimeter trap lines were compared using recaptures of tagged brown tree snakes. No differences were found among the different spacing distances for the distribution of recapture times. The results indicate that for some situations, snake trapping may be extended or made more efficient by increasing the distances between traps.

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1. Introduction

The brown tree snake (*Boiga irregularis*) is a worst-case example of the effects that an introduced predator can have on insular fauna (see, for example, Engeman and Vice, 2001). Since the inadvertent introduction of this species to Guam in the 1940s (see, for example, Rodda et al., 1992), it has been responsible for the extirpation or substantial reduction of the forest birds (Savidge, 1987), bats (Wiles, 1987) and native lizard species (Rodda and Fritts, 1992). It also has become a problem for the local poultry market (Fritts and McCoid, 1991), a major problem for electrical utilities (Fritts et al., 1987) and a public health and safety risk (Fritts et al., 1990). The importance of Guam as a shipping hub in the Pacific, coupled with the fragility of the other Pacific island ecosystems to which much of the outgoing cargo flows, has made the potential spread of the brown tree snake from Guam a serious concern.

Trapping is central to snake removal that is carried out at air and sea port facilities to curtail the dispersal of the snakes from Guam. While efficacy has been described for many aspects of the trapping efforts (Engeman and Linnell,

1998; Engeman et al., 1998a,b,c), much remains to be learned about improving its efficiency. Trapping is labour-intensive and improvements in efficiency could have a great impact on the capability to prevent the spread of brown tree snakes from Guam and the prospects for reclaiming forested land on Guam for native species. The present study reports on research undertaken to examine whether trap intervals on a brown tree snake trap line could be increased without loss of capture efficacy.

2. Methods

The study was conducted during March and April 1996 in the Conventional Weapons Storage Area (CWSA) at Andersen Air Force Base, Guam. This area was characterized by a secondary limestone forest habitat divided into rectangular units by paved roads. Three units (approx. $135 \times 915 \text{ m}^2$) were selected in the central portion of the CWSA that had never been trapped, and where adjacent units had also never been trapped. None of the selected units were adjacent to each other: at least one other untrapped unit was situated between those used in the study.

To create a single study plot in the three units, firstly, the forest perimeter of each unit was measured and then a single trail cut through the forest across each unit, positioning it so that the forest perimeters plus the trail were of nearly

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equal length for each of the three study plots, i.e. approx. 1300 m.

The forest perimeters plus bisecting trails were used in each plot as trap placement routes. Perimeter trapping was selected because this trapping strategy had proved to be an efficient and effective method and was used extensively in operational control (Engeman and Linnell, 1998; Engeman et al., 1998b,c). A spacing of 20 m (61 traps), 30 m (43 traps) or 40 m (34 traps) was randomly assigned to the three plots. The traps used were modified crawfish traps with one-way doors made of stamped metal (Linnell et al., 1998a,b). A live mouse protected in an interior cage of the trap served as an attractant.

The first 25 snakes captured from each plot (75 in total) were implanted with microchip identification tags (MITs), each with a unique identification number, and released approx. 10 m into the interior of the same plot near the site of capture. MIT number, the plot and the release date were recorded for each marked snake at the time of release. All subsequent snakes captured were scanned for MIT markers, and the date of recapture and the plot in which the recapture was made recorded. Trapping was continued for four weeks after the last marked snake was released (a total of 5 weeks of trapping).

The proportion of marked snakes recaptured for the different trap spacings were compared using Pearson's chi-square. Times to recapture were analysed using product-limit life table methods (Kaplan and Meier, 1958), with survival curves compared using the Wilcoxon statistic (Kalbfleisch and Prentice, 1980). Capture–recapture estimates were calculated using the programme NOREMARK (White, 1996) to index the initial population levels in each plot. Exponential decay regressions were fitted to the total capture data to describe declining captures (by week).

3. Results

Recapture percentages of the 25 marked snakes were similar among the plots with 20-, 30- or 40-m spacings (52%, 60% and 60%; $\chi^2 = 0.436$, $df = 2$, $p = 0.804$). Logistics did not permit simultaneous tag and release of all marked snakes in the study, so recapture opportunities were not identical for all marked snakes among the plots. Accordingly, the analyses of the distribution of time until recapture gave more useful information for comparing trap spacings. Even so, no differences were detected between the product-limit survival curves for comparing recapture times among the plots (chi-square for Wilcoxon test statistic = 0.879, $df = 2$, $p = 0.64$).

The number of snakes caught in the 40-m plot was roughly one-half of the numbers caught in the other two plots (Table 1). However, the mark-recapture index of the initial brown tree snake population (and density) in the 40-m plot was also roughly one-half of that for the other two plots (Table 1). The numbers of snakes captured from each of the plots

Table 1

Numbers of new captures of brown tree snakes in Guam, 1996 from 3 plots trap spacings each week, mark-recapture population estimates for each plot, and exponential model fitting results for declining captures using: captures = $a \times e^{b \times \text{week}}$

Week ^a	Trap spacing (m)		
	20	30	40
1	59	65	38
2	19	18	5
3	8	14	7
4	8	11	2
5	5	11	0
Total captures	99	117	52
Capture–recapture results			
Population estimate	103	120	58
95% confidence limit	74–167	84–191	45–87
^b Rectangular area (ha)	6.1	5.3	6.1
^b Density estimate (snakes ha ⁻¹)	16.9	22.6	9.5
Model fitting results			
Scale parameter, <i>a</i>	4.39	4.68	3.81
Rate parameter, <i>b</i>	–0.025	–0.025	–0.037
Coefficient of determination, <i>R</i> ²	0.88	0.81	0.81

^aWeek 1 had 8 nights trapping, all other weeks 7 nights.

^bRectangular area was calculated rather than the area in the irregular forest perimeter.

were a similar proportion (90%) of the corresponding initial population-size index values.

Numbers of new captures (recaptures excluded) decreased in each plot through each week of trapping (Table 1). The decline in captures for each plot was well modelled by an exponential decay curve:

$$\text{captures} = a \times e^{b \times \text{week}}.$$

The scale parameter, *a*, the rate parameter, *b*, and the coefficient of determination, *R*², for the three plots were also similar (Table 1).

4. Discussion

In examining the above results, we should first consider that there is more than one explanation for differences in capture rates not being found between the different trap spacings. Perhaps each trap has an attraction radius of at least 20 m. If so, a snake captured in the 20-m spacing would also have been susceptible to a 30- or 40-m spacing. An alternative explanation might relate more to snake activity. Even if the radius of attraction to a trap is very short, normal levels of activity for brown tree snakes would possibly make them likely to contact and enter traps spaced at 40 m. Because a snake would only be caught once, a lesser spacing would not improve efficacy. Another possibility is that these results were achieved because the study plots were narrow enough

to increase the chances that snakes would be on the forest perimeter for a high percentage of the time, and therefore were not rigorous comparisons of the trap spacings. Each of these somewhat different explanations is more easily envisaged on a perimeter trap line if brown tree snakes behave, as speculated by Engeman et al. (1998c), by tending to move along a forest edge when they contact it.

The 30- and 40-m spacings in this study performed as well as the 20-m spacing, which is the standard used for snake removal. Potentially, these results have substantial implications for deterring the spread of brown tree snakes from Guam, and for reclamation of large forested areas on Guam for the native species affected by brown tree snakes. Trapping has been demonstrated to be highly effective for snake removal (Engeman et al., 1998a,b). However, even as trap designs and maintenance methods improve (Linnell et al., 1998a,b), trapping remains a highly labour-intensive endeavour. An increase in trap spacing of 50% (to 30 m) or 100% (to 40 m) would represent a similar increase in efficiency for the operational trapping programme on Guam. Such an increase in efficiency would allow an extension of trapping resources to cover a greater area where the risk of snakes entering Guam's outbound cargo flow is greatest. Similarly, coverage of greater areas of contiguous forested plots by trapping could also produce sufficient habitat suitability for preservation or recovery of native species.

The challenge is to translate the information from this study into a practical application for the operational control of brown tree snakes on Guam. It must be borne in mind that the 20-m spacing has served well for operational control, and we are only aware of no other trial than the present that has compared different inter-trap spacings in an operational context. Thus, trap lines in areas of less high risk for snake export, such as housing areas, might have their spacings increased to obtain greater coverage. Similarly, trap lines used for maintaining low populations on blocks of land where brown tree snakes have largely been removed (Engeman et al., 1998a) might also employ greater spacing. Spacings in narrow plots, say < 70 m in width, also might be trapped successfully with wider spacings between traps. Until further investigations under a variety of circumstances confirm our results, permanent changes to an operational trapping regime that is performing well should be resisted in locations that present a high risk for introduction of brown tree snakes to outbound cargo from Guam, e.g. adjacent to air and sea port cargo-handling facilities.

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